

THE NOT-SO-SUDDEN RESULTS OF THE SUDDEN SAW LOG STUDY— GROWTH AND YIELD THROUGH AGE 45

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Abstract—The Sudden-Saw Log Study, located near Crossett, AR, was established to test the hypothesis that loblolly pine plantations can produce sawtimber on good sites in 30 years. Study measurements reported at stand age 33 years showed that the hypothesis is true. Fortunately, the study was not terminated at that time. Inventory data were also collected at stand ages 36, 39, and 45 years. By stand age 45, average Doyle board-foot volume sawtimber yields for all treatments were not significantly different, averaging 21,889 bf/acre, although the mean diameter of trees that received intensive management (20.4 inches) was 38 percent greater than that of trees receiving the control treatment (14.9 inches). The control treatment always produced the greatest cubic-foot volume (9,422 ft³ at age 45), and after age 33 led all other treatments in predicted financial returns.

INTRODUCTION

In February 1954, a 9-year-old loblolly pine (*Pinus taeda* L.) plantation located on an abandoned cotton field near Crossett, AR, was selected for use in a growth-and-yield study (Burton 1982, Burton and Shoulders 1974). The stand had been planted at a spacing of 6 ft by 6 ft (1,210 trees/acre) in 1945. By 1954, survival averaged 1,100 trees/acre, and the 50-year site index was projected to be between 90 and 100 feet. The study objective was "...to determine whether a plantation on a good site (site index = 90) could be managed to produce good quality sawtimber on a short rotation by combining early thinning, understory vegetation control, and pruning" (Baker and Bishop 1986).

The study was officially closed at age 33. Results were reported in Burton and Shoulders (1974), Burton (1982), Taylor and Burton (1982), and Baker and Bishop (1986). However, the stands were never cut and the trees were remeasured at ages 36, 39, and 45. Management, except for occasional mowing of the plots to facilitate tours, had discontinued at age 30. This paper reports the effects of stand treatments on growth and yield since study inception, with emphasis on results at the later ages.

METHODS

Four thinning treatments were replicated three times in randomized blocks. Two treatments began immediately (at age 9) and two began at age 12, when the average tree had attained merchantable pulpwood size. The four treatments were:

Sawtimber only—All noncrop trees and all but 100 crop trees/acre were cut at age 9. Stands were thinned every 3 years thereafter to 76 trees/acre by age 19 and to 41 trees/acre at age 30.

Sawtimber pulpwood—Thinnings at age 9 and 12 removed noncrop trees whose crowns were within 5 feet of crowns of the 100 crop trees. The last noncrop trees were removed at age 15. Further thinnings at 3-year intervals left 80 trees/acre at age 19 and 52 trees/acre at age 30.

Delayed sawtimber—Stands were reduced to 100 crop trees/acre at age 12 and thinned every 3 years thereafter until 45 trees/acre remained at age 30.

Control—Plots were thinned, mainly from below, to a basal area of 85 ft²/acre at age 12 and every 3 years afterward through age 30. The thinnings reduced stand density from 712 stems/acre at 12 years to 116 stems/acre at 30 years.

The timing and severity of later thinnings were based on periodic d.b.h. growth. Crop trees in the intensive-treatment plots were pruned from the ground to about one-half their total height after the first thinning and every 3 years afterward until clear length averaged 33 feet at age 24. Also, beginning at age 19, the woody understory was mowed every 2 years in the intensively managed plots.

MEASUREMENTS AND ANALYSIS

The d.b.h. of all trees was obtained at every measurement date. Total height and height to the base of the live crown, for all crop trees, were measured from age 12. Volumes reported in earlier papers were read from a standard volume table (USDA Forest Service 1976) for stands aged 12 to 18 and were calculated by the STX Program (Grosenbaugh 1967) for stands aged 21 to 33. All total inside-bark cubic-foot volumes and Doyle inside-bark board-foot volumes (merchantable height to an 8-inch inside-bark top diameter) reported here were calculated by means of volume and taper equations (Baldwin and Feduccia 1991). The Doyle board-foot volume measure was selected because its use is mandated by law in timber sales in most of the Southern United States (Baker and Bishop 1986). Volume yields included the accumulated cut yields for each of the treatments.

Yield curves were developed by fitting nonlinear regressions to the volume yield data. The model was $\text{yield} = a[1 - \exp(-b \cdot \text{age})]^c$, where a , b , and c are the parameters estimated. Mean and periodic annual volume increments, MAI and PAI, respectively, were then calculated from these smoothed curve values. The mean diameters reported are

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prethinning values for each measurement period; the use of prethinning values minimizes the effect that thinning from below has on diameter. Differences among treatment means were tested by analysis of variance and Duncan's multiple-range test at the $\alpha=0.05$ level (SAS Institute 1989).

Pretax soil expectation values (SEV's) for harvest ages 30, 33, 35, 39, and 45 were calculated for each treatment so that the economics of the treatments could be compared. Current costs of management activities were gathered from forest managers, scientists, and vendors of forestry services. Louisiana stumpage prices for sawtimber and pulpwood were taken from estimates made by Timber Mart South, Inc. For each harvest, stumpage prices over a 2-year period were averaged to minimize the impact of stumpage price fluctuations on the analysis. The stands were not fully merchandized for quality products that might be obtained from stands of heavily pruned larger diameter timber. A more definitive analysis might include analysis of timber quality and a more thorough consideration of the impact of logging costs.

Some of the procedures or practices employed in the study and reflected in the economic analysis, such as the close 6-ft by 6-ft planting density, frequent mid-rotation mowing to control vegetation, and a two-log pruning regime, are not considered cost effective and thus are not utilized in the present economic climate. The fixed costs of holding the land in forestry—property taxes and miscellaneous management costs—were also not considered in this analysis. The total investment costs of the sawtimber-only, sawtimber-pulpwood, and delayed-sawtimber treatments exceeded \$660/acre, whereas the total investment cost for the control treatment was only \$161/acre. A real discount rate of 4 percent was used to calculate SEV's. The assumption was made that all prices and costs increased at the rate of inflation.

RESULTS

Only the control treatment was thinned to a target basal area before age 27, so the residual basal areas for the other treatments varied, mainly according to the number of trees cut at each thinning. Basal area was always highest for the control treatment. At age 45, basal area for the control treatment was about 40 ft²/acre more than basal areas for the sawtimber-only and delayed-sawtimber treatments (98 ft² and 102 ft², respectively), and about 30 ft²/acre more than the basal area for the sawtimber-pulpwood treatment (109 ft²).

Quadratic mean diameter (d.b.h.) was highest for the sawtimber-only treatment throughout the study. The age-45 diameters for all of the intensive treatments did not differ significantly from treatment to treatment (fig. 1). The mean diameter for the control treatment (14.9 inches) was 27 percent less than the average for the other three treatments (20.4 inches). Thus, trees in the intensively managed stands reached sawtimber size before the others did and maintained at least a 27-percent size advantage from age 18 through age 45.

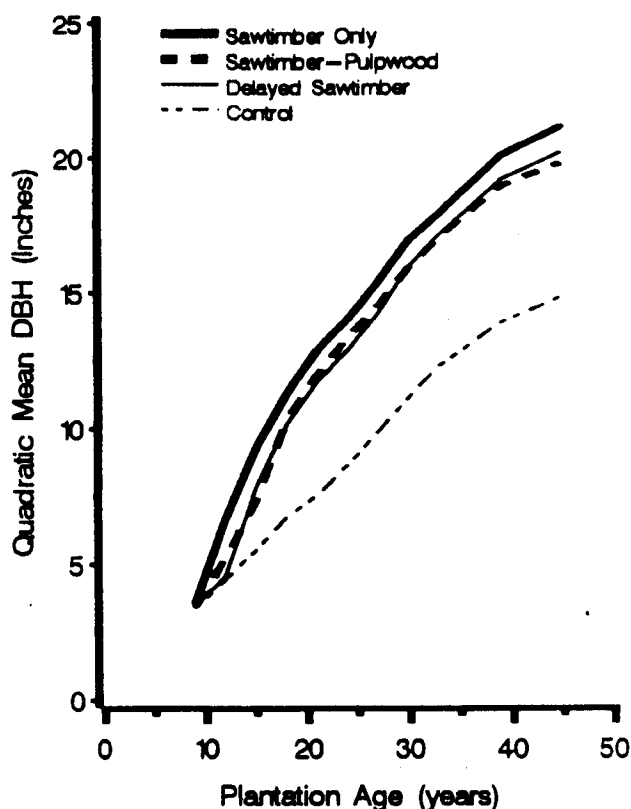


Figure 1—Trends in prethinning quadratic mean diameter. Lines join data points for the remeasurement years.

There was no significant difference in mean total crop-tree height between treatments at any remeasurement year. Height averaged 94 feet at age 45. Extrapolation of these results suggests that total height will be near 100 feet at age 50, indicating that site index for the study plots is at the upper end of the range predicted (90 to 100 feet) at study installation (Burton 1982).

As would be expected, the control treatment always carried the highest total cubic-foot volume because it had the most trees per acre throughout the study. At age 45, total volume yield for the control treatment was 9,422 ft³/acre, compared to an average yield of 6,642 ft³/acre for the intensively managed treatments. These treatment yields, and those reported below, include all volumes cut at earlier ages.

At age 30, when this study was designed to end, the intensive treatments had produced about twice the board-foot volume produced by the control treatment (table 1). Fifteen years later, however, board-foot volume for the control treatment, (19,778 bf/acre) had nearly caught up with the average volume yield of the other treatments (22,592 bf/acre) and was not significantly different from the other yields. Board-foot volume production of the control stand may even exceed that of the intensively managed stands in a few years (fig. 2). However, all treatments were near their predicted maximum level of annual board-foot volume productivity, so quantitative extrapolations are not warranted. Mean annual increment for cubic-foot volume maximized at age 32 for the delayed-sawtimber treatment, while the

Table 1—Saw log volume yield^a in Doyle board foot per acre for each measurement age and treatment

Plantation age	Treatment ^b			
	Sawtimber only	Sawtimber pulpwood	Delayed sawtimber	Control
<i>Years</i>				
9	0	0	0	0
12	0	0	0	0
15	176	0	13	0
18	2,008	1,007	869	24
21	3,998 a	2,836 b	2,937 b	116 c
24	6,329 a	5,228 b	5,378 b	995 c
27	8,955 a	7,897 b	8,078 ab	2,846 c
30	11,415 a	10,402 a	10,335 a	5,151 b
33	13,527 a	12,903 a	12,699 a	8,034 b
35	14,811 a	14,636 a	14,577 a	9,928 b
39	18,663 a	18,759 a	18,468 a	14,614 b
45	22,622 a	22,611 a	22,544 a	19,778 a

^a Yield is the total board-foot volume at the listed age plus the sum of all previously harvested volume

^b Treatment means for ages 21 and above were tested for statistically significant differences with $\alpha=0.05$ using Duncan's multiple-range test. Means in the same row succeeded by the same letter are not significantly different (SAS Institute 1989).

maximum was achieved at age 35 for all other treatments. The maximums for Doyle board-foot volume are projected to occur at about age 48 for the intensively managed treatments and at age 52 for the control treatment (fig. 3).

Despite the very high investment costs of the intensive-management treatments, the SEV's of these treatments were high and reached a maximum at plantation age 39 (table 2). The delayed-sawtimber stand had the highest SEV (\$1,892/acre) among the three high-investment treatments, followed by sawtimber-pulpwood (\$1,867/acre) and sawtimber-only (\$1,732/acre). The control treatment, which was inexpensive to establish, had the highest SEV (\$2,049/acre).

DISCUSSION AND CONCLUSIONS

The most significant change since the report by Burton (1982) at stand age 33 was the increase in board-foot volume and value of the timber in the control-treatment plots. That treatment passed the others financially after 33 years of growth. Of course this trend was not unexpected—only the time of occurrence was unknown. In their report of the age-30 results, which included an analysis showing that the intensive-management treatments were the best financial investment, Baker and Bishop (1986) stated: "...if the rotation were lengthened to 40 or 50 years, the results of the financial analyses would change markedly, with the

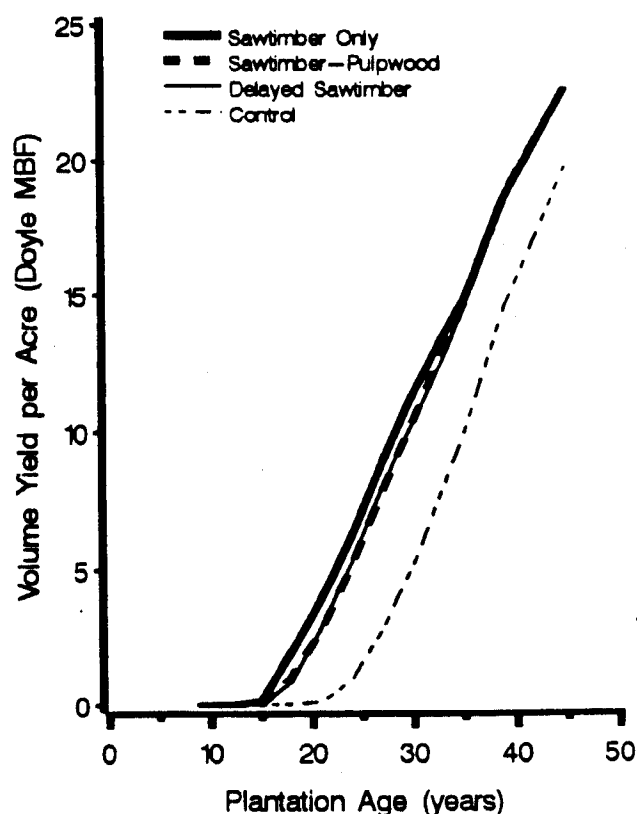


Figure 2—Trends in inside bark, Doyle board-foot volume yield per acre through age 45. Lines join data points for the remeasurement years.

Table 2—Soil expectation values (4-percent discount rate) for each treatment at each inventory starting from age 30

Treatment	Plantation age (years)				
	30	33	35	39	45
----- Dollars -----					
Sawtimber only	1,502	1,591	1,606	1,732	1,636
Sawtimber-pulpwood	1,535	1,674	1,737	1,867	1,727
Delayed sawtimber	1,548	1,683	1,775	1,892	1,791
Control	1,482	1,721	1,828	2,049	2,036

conventional management undoubtedly improving in investment ranking."

However, our financial analysis does not necessarily show that intensive management does not pay. Management costs could be lowered considerably. For example, the intensive-management plots could have been established with fewer trees/acre, pruning fewer times to a one-log height, and mowing less often or not at all. Also, it may be the case that the proportion of export-quality sawtimber is higher for the intensive treatments than for the control treatment, thus implying higher value of the intensive

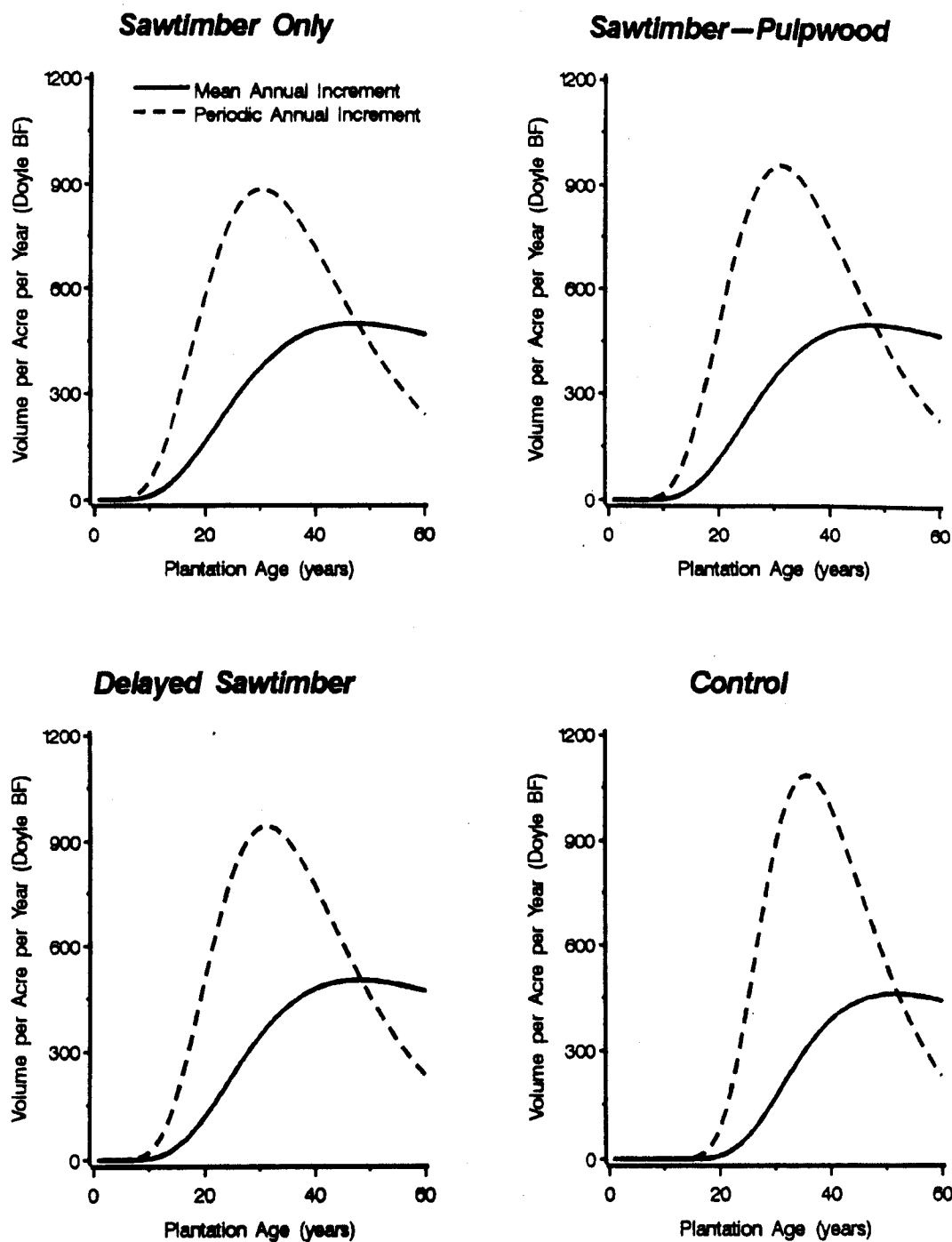


Figure 3—Regression curves for mean and periodic annual increment in Doyle board-foot volume per acre. Curves are extrapolated to stand age 60.

treatment products. Any of these adjustments could make the intensive management scenarios more profitable.

The objective of achieving sawtimber-sized loblolly pine on good sites in 30 years or less is indeed obtainable and can be obtained profitably. However, measurements made at older stand ages show that overall profits can be greater for conventionally managed stands than for intensively managed ones if stands are not harvested by age 33. It is recommended that, as Baker and Bishop (1986) proposed

earlier, landowners employing sudden-saw log silviculture use wider planting spacings, commercial thinning only, pruning of only the very best trees to just one log-length, and early understory control to insure maximum production. Additionally, site preparation and fertilization should be considered for use on cutover lands.

LITERATURE CITED

- Baker, James B.; Bishop, Larry M.** 1986. Crossett Demonstration Forest guide. Gen. Rep. R8-GR 6. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 55 p.
- Baldwin, V.C., Jr.; Feduccia, D.P.** 1991. Compatible tree-volume and upper-stem diameter equations for plantation loblolly pines in the West Gulf Region. *Southern Journal of Applied Forestry*. 15(2): 92-97.
- Burton, James D.** 1982. Sawtimber by prescription—the sudden sawlog story through age 33. Res. Pap. SO-179. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 9 p.
- Burton, James D.; Shoulders, Eugene.** 1974. Fast-grown, dense, loblolly pine sawlogs: A reality. *Journal of Forestry*. 72(10): 637-641.
- Grosenbaugh, L.R.** 1976. STX-FORTRAN-4 program for estimates of tree populations from 3P sample-tree measurements. Res. Pap. PSW-13, rev. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 76 p.
- SAS Institute, Inc.** 1989. SAS/STAT user's guide, version 6, 4th ed., vol. 2. Cary, NC: SAS Institute, Inc. 846 p.
- Taylor, Fred W.; Burton, James D.** 1982. Growth ring characteristics, specific gravity, and fiber length of rapidly grown loblolly pine. *Wood and Fiber*. 14(3): 204-210.
- U.S. Department of Agriculture, Forest Service.** 1976. Volume, yield, and stand tables for second-growth southern pines. Misc. Pub. 50, rev. Washington, DC: U.S. Department of Agriculture, Forest Service. 202 p.

